Groundwater Quality in Kentucky: 2,4-D

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Introduction

2,4-dichlorophenoxyacetic acid, commonly known as 2,4-D, is an herbicide used for selective control of broadleaf and grassy weeds in crops such as corn and wheat, along roadways and rights-of-way, and on pasture and rangeland. 2,4-D is the most widely used herbicide in the world, and the third most widely used in North America after metolachlor and atrazine. 2,4-D is a synthetic, organic, white to yellow, odorless, crystalline powder that dissolves readily in water. It is widely used today primarily because of its low cost.

2,4-D was a major component (about 50 percent) in Agent Orange, a defoliant used extensively during the Vietnam War. Most of the subsequent health problems associated with Agent Orange were caused by the contaminant dioxin in the 2,4,5-T component of Agent Orange, however (Cornell University Cooperative Extension Office, 1993).

2,4-D enters the environment as an airborne spray on crops, and can be absorbed from soil by plants. It normally breaks down rapidly: the half-life of 2,4-D is 1 to 2 weeks in soil and 1 to 3 weeks in water. It kills plants by mimicking the natural plant growth hormone auxin. Rapid cell growth occurs after application, causing plants to die when their transport systems are blocked by the abnormal growth (Hess, 1993).

The health hazards of 2,4-D exposure depend on the amount of toxin and the length of time a person is exposed to the chemical. The U.S. Environmental Protection Agency has set a maximum contaminant level for 2,4-D of 0.07 mg/L. Acute exposure (a single exposure higher than the MCL) can result in nervous-system damage. Chronic or long-term exposure to 2,4-D at levels over the MCL may result in damage to the nervous system, kidneys, and liver (U.S. Environmental Protection Agency, 2006). Repeated exposure can also cause headache, fatigue, muscle weakness, poor arm/leg coordination, nausea, vomiting, diarrhea, stomach pain, and weight loss (New Jersey Department of Health and Senior Services, 1999).

Concentrations in Groundwater

Data Sources

Data for this report were compiled from the Kentucky Groundwater Data Repository, maintained by the Kentucky Geological Survey. The repository was established in 1990 to archive and disseminate groundwater data collected by various agencies in Kentucky. Major data sources for the repository include the Kentucky Division of Water, the Kentucky Geological Survey, the U.S. Geological Survey, the National Uranium Resource Evaluation Program, and the U.S. Environmental Protection Agency.

The repository contained 2,165 analyses of 2,4-D from 167 wells and 210 springs throughout Kentucky as of June 2007 (Table 1). Data from sites of known or suspected contamination (samples collected for the Resource Conservation and Recovery Act, Superfund, Solid Waste, or Underground Storage Tank programs) were not included.

Table 1. Summary of 2,4-D concentrations.

Region	No. of Measurements	No. of Sites	No. of Sites with 2,4-D Detected	No. of Sites > 0.07 mg/L
Inner Bluegrass	353	62	8	0
Outer Bluegrass	274	58	6	0
Knobs	66	11	1	0
Eastern Ky. Coal Field	351	76	1	1
Western Ky. Coal Field	141	22	1	0
Jackson Purchase	96	21	0	0
Eastern Pennyroyal	96	26	0	0
Western Pennyroyal	788	101	8	0

Nearly 98 percent of the results were less than analytical detection limits, which ranged from 0.000005 mg/L for recent measurements to 1.22 mg/L for older analyses. 2,4-D was detected in 22 springs and three wells, at concentrations ranging from 0.000084 to 0.954 mg/L. One measurement from a site in the Eastern Kentucky Coal Field exceeded the MCL of 0.07 mg/L. More than 99 percent of all measurements were less than 0.015 mg/L (Fig. 1).

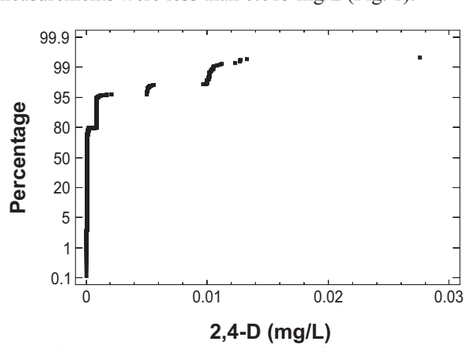

Figure 1. Cumulative percentage plot of 2,4-D values. Higher values were excluded to better show the majority of the data. MCL=0.07 mg/L.

Regional Variations in 2,4-D Concentrations

The map shows sites where 2,4-D was sampled; different symbols show concentration ranges. Sites that have been sampled more than once may have more than one symbol, and symbols may overlap if the sites are close to each other. Concentrations that were less than analytical detection limits indicate that 2,4-D was tested for but not found at that well or spring. Sites in the Inner Bluegrass, Outer Bluegrass, and Western Pennyroyal Regions accounted for 22 of the wells and springs where 2,4-D was detected..

Figure 2 summarizes the 2,4-D concentrations for each physiographic region. Values below analytical detection limits were not plotted. Boxes enclose the central 50 percent of the values, the median value is shown by a vertical line through the box, and lines extend from each edge of the box for a distance of 1.5 times the concentration range represented by the central box. Values beyond this range are shown as individual squares. The Knobs and the Western Kentucky Coal Field each had one site where 2,4-D was detected.

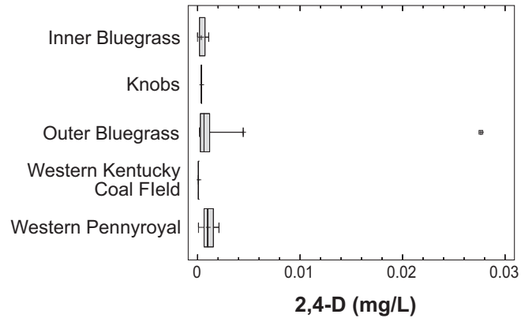

Figure 2. Box-and-whisker plots of 2,4-D values for the major physiographic regions. Only values greater than the analytical detection limit are shown. One value of 0.954 mg/L from the Eastern Kentucky Coal Field was excluded to better show the majority of the data. MCL=0.07 mg/L.

Twenty-one springs and three wells had detectable 2,4-D; groundwater from springs had higher 2,4-D concentrations and a larger range of values than water from wells (Fig. 3).

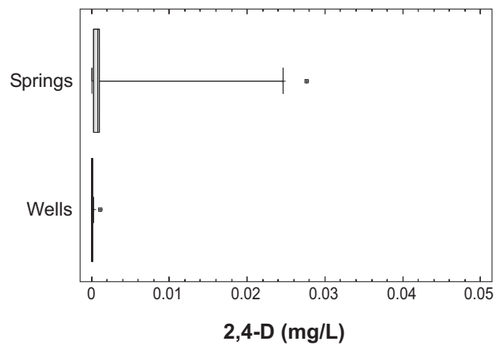

Figure 3. Comparison of 2,4-D concentrations in water from wells and springs. Only values greater than the analytical detection limit are shown. One value of 0.954 mg/L from a spring in the Eastern Kentucky Coal Field was excluded to better show the majority of the data. MCL=0.07 mg/L.

Water-Quality Concerns

The pesticide 2,4-D was detected at only 25 of 377 sites and exceeded the MCL at only one site. Most of the sites where 2,4-D was detected are springs; wells where 2,4-D was found are all less than 140 ft deep. Concentrations greater than the analytical detection limit occurred primarily in the carbonate, karst terrain of the Inner Bluegrass, Outer Bluegrass, and Western Pennyroyal Regions, where agriculture is common, soils are thin, and solution channels allow rapid transport from land surface to shallow groundwater.

2,4-D concentrations exceeded the MCL at only one site, a spring in the Eastern Kentucky Coal Field. Records from the Kentucky Groundwater Data Repository indicate the spring issues from Mississippian limestone, probably from a solution channel in the carbonate rock. The spring was sampled 21 times from 1994 to 2003, and only once (in 2002) was 2,4-D detected. Subsequent sampling in 2003 did not detect 2,4-D. These records suggest that the occurrence of high 2,4-D levels once over a 10-year period is an anomaly and the spring is not permanently contaminated.

Although more than 90 percent of the sampled sites showed no detectable 2,4-D, the presence of this pesticide at a few sites shows some contamination of the shallow groundwater system.

These findings should be viewed as general patterns. Individual wells or springs should be tested for the occurrence of 2,4-D and other potential contaminants before being used as drinking-water supplies. Citizens with concerns about the quality of water in private wells or springs should contact their local health department or the Groundwater Branch of the Kentucky Division of Water, a division of the Kentucky Natural Resources and Environmental Protection Cabinet. The Groundwater Branch can provide literature on maintaining private wells and springs and information on sampling for water-quality analysis. The Kentucky Groundwater Data Repository receives new results of analyses periodically. To view the latest data, visit kgsweb.uky.edu/DataSearching/watersearch.asp.

The Kentucky Interagency Groundwater Monitoring Network

This publication is a product of the Kentucky Interagency Groundwater Monitoring Network, which was established in 1998 by legislation (KRS 161.625) to collect groundwater quality data, characterize groundwater resources, and distribute the resulting information. The network is assisted by an Interagency Technical Advisory Committee on Groundwater, which was also created by statute (KRS 151.629). Additional information and a list of member agencies can be found at www.uky.edu/KGS/water/gnet/gnet.htm.

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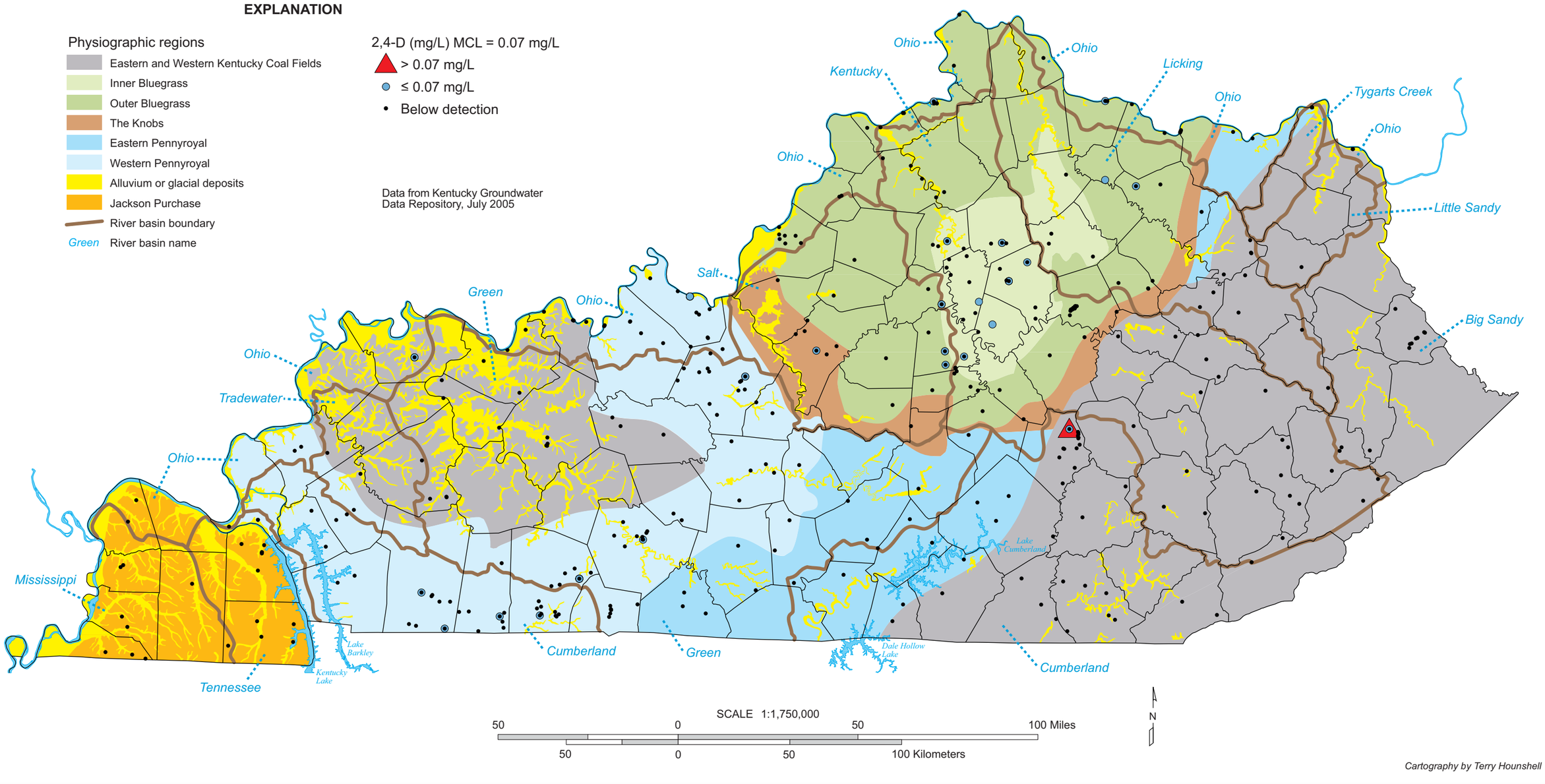
2,4-D CONCENTRATIONS IN WELLS AND SPRINGS IN KENTUCKY



Cartography by Terry Hounshell